

# M-learning Architecture for Cloud-based Higher Education System of Bangladesh

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## Abstract

The prevalence of wireless technologies in education leads to increasing research interest in M-learning that blends wireless technology and mobile computing to educate the world. On the other hand, Cloud computing is the latest effort in delivering computing resources as a service. Using an integrated approach based on Cloud Computing may be a solution to obtain the agility and quick access to technologies, with the achievement of savings at an institution level. This paper presents a new architecture for a mobile distance learning system in an extended cloud computing environment enriched with mobiles and wireless devices. The architecture can be applied everywhere where there is a need for intensive teaching and learning in higher education. The system architecture is described, together with the discussions of its possibilities and potential issues. In addition, the adoption possibility and simultaneously the barriers for cloud based higher education system for Bangladesh have been explored.

## Keywords

Cloud Computing; Information Technology; Framework; Architecture; M-learning

## Introduction

With the explosive and rapid growth of the Internet, mobile networks, mobile applications, and cloud computing, cloud based mobile learning was introduced as a potential technology for mobile devices. Mobile devices, in particular the mobile phone, are ubiquitous amongst the whole world population. Worldwide, Universities are experimenting with the potential mobile devices to broaden teaching and learning opportunities and reach more diverse, and technology awareness, learners. As mobile network infrastructures continuously improve, their data transmission becomes increasingly available and affordable, and thus becoming popular clients to consume any web based applications. Cloud computing provides

delivery of services, software and processing capacity over the internet, reducing cost, increasing automating systems, decoupling of service delivery from underlying technology, and providing flexibility and mobility of information. Cloud based m-learning integrates the cloud computing into the mobile environment and overcomes the obstacles related to the performance, environment and security [Sclater (2010)], where the students can get the knowledge from centralized shared resources at any place and any time [Al-Sharhan (2010), Al-Zoube (2009)]. Compared to the traditional server-based model, the resources and services in cloud computing are acquired from a pool termed "cloud". From a simple perspective, cloud based mobile learning can be thought of as an infrastructure where data and processing could happen outside of the mobile device, enabling new types of applications such as context-aware mobile social networks. As a result, many mobile cloud applications are not restricted to powerful smart phones, but to a broad range of less advanced mobile phones and therefore, to a much larger subscriber segment.

This paper presents a new architecture of mobile Learning System in Cloud Computing Environment, by using technologies enriched with mobile and wireless devices, addressing the challenges and overcoming the existing limitations of m-learning. The proposed architecture supports educational institutes with diverse learning styles in different learning contexts in order to facilitate lifelong learning and information/knowledge sharing accumulated through cloud based systems. As mentioned above, cloud-based education requires not only technology support but also a need to distil it into a practical, consistent, accessible architecture. This paper discusses survey from Bangladesh higher educational institutions and their willingness to engage with mobile technology

and content in an educational sense. It is concluded with recommendations to move forward which may be applicable to inform institutional policy and practice at other universities. Therefore, the contributions of this paper are as follows.

- Describe the interactive learning mode in a cloud environment by using the proposed architecture in order to demonstrate the combined advantages of better interaction facilities of a new system;
- Explore the relationships between cloud-based learning and m-learning in order to gain more thorough understandings of cloud based learning, and
- Provide a suitable approach with a strategy for a cloud computing based m-learning system adoption in Bangladesh educational institutes, based on the findings of the survey.

The rest of this paper is organized as follows. Section II summarizes the related work. Section III presents the new architecture of m-learning system in a cloud computing environment. A survey is used to determine the factors affecting the cloud adoption process which is described in Section IV. Section V presents the criteria for cloud selection based on the survey. The paper finally concludes by comparing the results of this survey with similar studies and conclusion in details is in Section VI.

## Related Work

The combination of cloud technologies and m-learning has been scarcely explored. The most promising works are reviewed in this section.

In Japan, three studies were carried out to examine the use of cell phones in education [Chen & Lu (2010)]. In these studies students were surveyed regarding their uses of mobile phones, English vocabulary lessons were sent to the learners' mobile phones using SMS and a website was developed to explain the English idioms which students surfed using their 3G phones. The findings revealed that mobile phones are ubiquitous among students and learners have been ready to read small text on mobile screens.

Barker investigated the success of m-learning in developed countries and proposed a model to benefit the developing countries [Barker et al. (2005)]. With South African community and communication

infrastructure in mind, she identified the m-learning environment, concerned participants and factors crucial to the success of the model. According to her findings, the use of wireless technologies can result in motivation, collaboration, and portability for students, teachers, and parents.

At Shanghai Jiao Tong University, Qi [Qi (2006)] designed and implemented a mobile learning system that broadcasts the live class room environment to students' mobile phones via the GPRS network. Using the client software at cell phones, students were able to select the broadcasted materials based on GPRS network traffic. In a classroom, a teacher was able to view the cell phone screens of all connected students. The system also makes possible for teachers to communicate with students through SMS and instant polls.

Jian Li at [Li (2010)] summarized the characteristics and models of traditional mobile learning, analysed the features of cloud computing, and clarified the superiority of mobile learning model development in a cloud computing environment. Two kinds of mobile learning models were identified: an autonomous mobile learning model, and a reception mobile learning model. Xuefei Chen et al. [Chen et al. (2010)] summed up the traditional mode of mobile learning, analysed the characteristics of various patterns, provided the characteristics of the cloud computing, and then made mobile learning mode under a cloud computing environment. They then classified the learning modes into two types of acceptance-based mobile learning mode and autonomous mobile learning.

Luo Zhong et al. discussed the characteristics and key techniques of 3G mobile learning based on cloud services, mainly focusing on mobile learning modes including active mode, passive mode, and hybrid mode. The personalized learning method and resource integration approach were applied and analyzed. Further, they proposed the employment of cloud computing to mobile learning and built a basic framework and simulation application for 3G mobile learning based on cloud services.

J.C. Costa et al. presented an application named MLI (Mobile Lecture Interaction) for enhancing lecture interactions between a teacher and students. However, the mobile application allows the students to ask questions and support questions from other students by voting for them. These questions are presented to

an instructor application running on a PC, so that the instructor can then answer the question in details. In order to develop a new system with the combined advantages of above models such as better interaction facilities, reduced delay, here an architecture has been proposed which reflects interactive learning mode in a cloud environment.

In this paper, a new paradigm is highlighted in the educational area by introducing the cloud computing in the m-learning architecture in order to increase the scalability, flexibility, and availability of higher education systems by formulating a framework. In contrast, a cloud-based m-learning model introduced a scale efficiency mechanism, i.e., construction of m-learning system is entrusted to cloud computing suppliers, which can make providers and users achieve a win-win situation. The cloud-based environment supports the creation of new generation of m-learning systems, and runs on a wide range of hardware devices, while storing data inside the cloud. This paper also aims to investigate IT professionals' thoughts on cloud computing, and to explore the key factors that may influence the cloud adoption in the educational institutes of Bangladesh.

#### An Architecture of M-learning Based on Cloud

This architecture is proposed for higher education in a cloud computing environment. The main objective of Mobile-Learning in the cloud environment is to provide learners with the knowledge from the centralized shared resources at anytime and anywhere. Our proposed architecture for Mobile Distance Learning as shown in Fig. 1 incorporates the communication between end-user devices (terminals) and the Data Center in a cloud computing environment. The terminals can be connected to the Infrastructure inside the University Local Area Network (LAN), or they can be connected on external networks (the internet). The University Platform Server (Course Management System) [Masud & Huang (2010)] hosts educational resources and it is connected on the University LAN. A user may access the platform directly from the University LAN or through the Internet in order to collect learning materials. The user can access the Data center either from University LAN, or directly from the Internet. The authentication server manages the authorized access to the Data Center, and is directly connected on both passive and active servers as depicted in Fig 2.

The passive and the active servers need to be connected to the Load Balancer, determining which server is active. The Load Balancer determines which server needs to manage the load (either the active, or both), i.e. the incoming service request from the user. Both active and passive servers can be connected to a storage area network and the network infrastructure. The server takes additional data from the storage area network that needs to be processed. The advantage of this architecture is that it offers an interactive mode on mobile devices, as a special benefit from using the Data center within the mobile cloud environment.

In our case, another advantage of this model is that it can provide service continuity, or seamless mobility as the user handovers from the external network to the University Local area network. According to this architecture, the University classrooms are connected to the Server Platform and the Internet. The University Classroom usually should have the following equipments: A PC, or laptop, microphone, speakers, tablet, webcam, projector, and a monitor, or screen. At a University Classroom, a lecturer presents and delivers the content of learning materials to the students in a classical manner, or via the Internet to the students at home, at work, or simply they are mobile (on the road). The students at home, or at work can access to the course by using their PCs, or laptops using the high speed Internet from their homes, or their offices. On the other hand, the mobile students (students on the road) use their mobile devices (mobile smart phones, or tablets) to connect to the course via their mobile networks (such as GPRS, UMTS, HSPA, WiFi, WiMAX or LTE) which is shown in Fig 2. According to the technology development trend, increased speed and density of Integrated Circuits, Enhanced Transmission capacities on Optic Fibre Networks and Networking Flexibility, Distributed and Open Platform-based Communication Software, Capacity Growth and new Application Services on Wireless, Emergence of Next-Generation Networks (IP-based), Delivering QOS for Real time services, Ubiquity of networks through RFID & IPv6 (Next Generation Internet) are the demand of the age. In continuation to that use of Coaxial Cable for Telecom Services (Cable TV Network for Broadband and telephony local loop), Use of DSL technology on traditional Copper Loops, Wireless Access Service for Fixed and Mobile communication, VSAT-based Access in remote areas, Power line based Access (BPL), Free Space Optics (FSO) are also the continuation of the service trend.

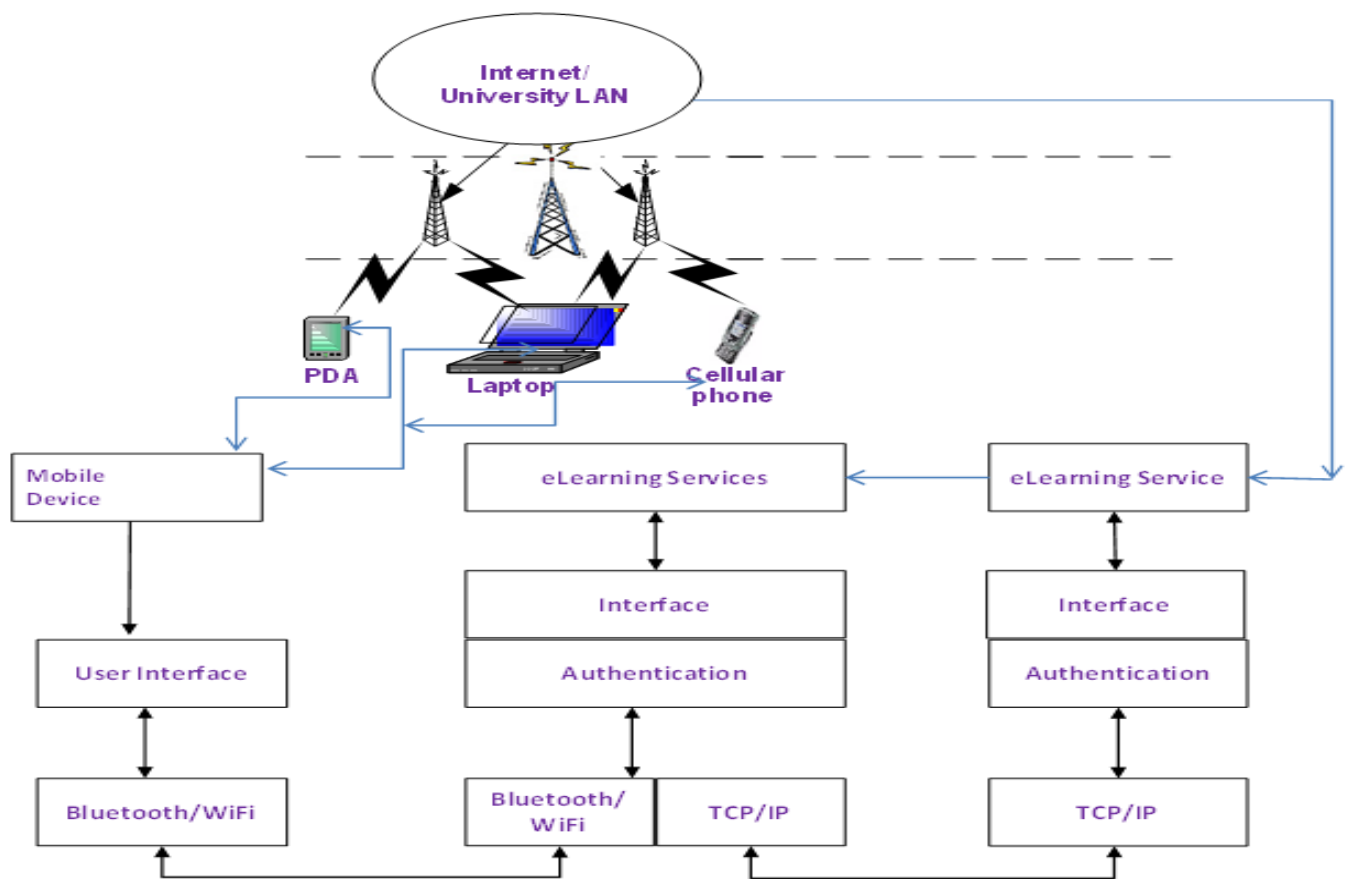


FIG 1. PROPOSED ARCHITECTURE FOR CLOUD BASED M-LEARNING

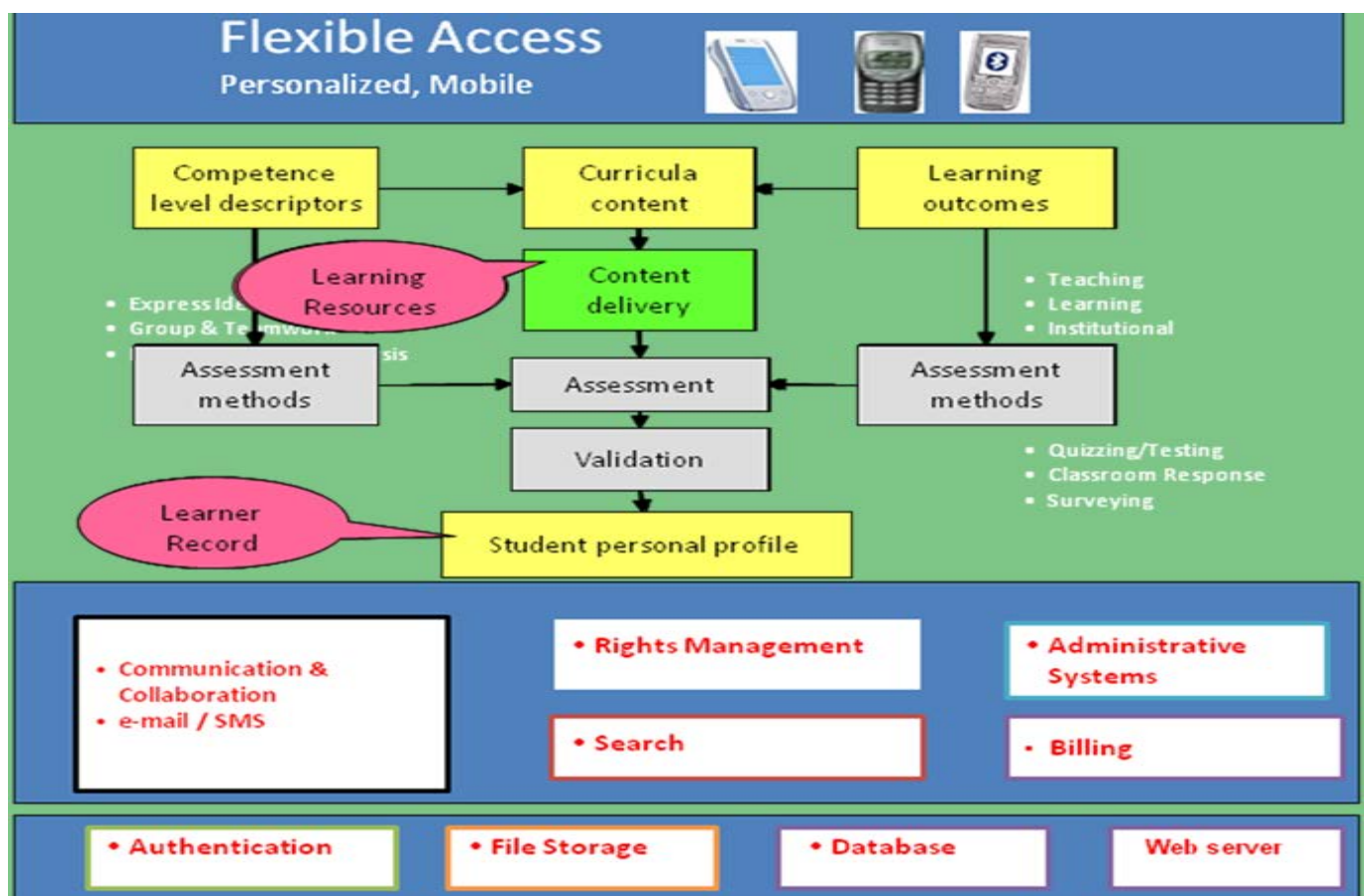


FIGURE 2. DETAILED COMPONENTS OF THE ARCHITECTURE

The Server Platform provides the possibility to host the digital educational resources, which can be accessed by the lecturer and all students either locally, or throughout the Internet. Additionally, all students, as well as the lecturer over the Internet can access the Server Platform to collect, or download the data that needs to be computed in a cloud computing environment. The components of the proposed architecture are mainly to solve the sharing of computing resources, which can be used as the e-learning resource library, which includes hardware, storage, and some other IT infrastructure and resource pool, by means of virtualization technology [Jamal (2009)], coordinating actions to ensure stability and reliability. At the same time, it provides the network supported environment to ensure the scalability and efficient use of resources in cloud computing applications. The service system is a software system of an actual run of storage, maintenance and provision of data, a collection of objects of storage medium, processing, and management system, and the web development integration platform.

In addition to the content network storage and maintenance, this also provides standard interfaces. When resources in the library have a rich accumulation and a certain amount of knowledge systems, there is a need for resource packages to form an independent resource platform to the upper access. The service system contains all the blocks implementing the local and distributed management functionalities of Education Cloud [Vouk (2005)]. The administration and authentication unit provides and implements the Cloud's access facilities. This task falls into the security scope of identification, authentication, and permission management. Since designing a cloud system is not purely a matter of technical sophistication, the incorporation of a strategic framework necessitated into the process of system design. The strategic framework should include various aspects that should be considered in designing a cloud system [Masud & Huang (2012)].

On the other hand, the cloud in M-learning plays a vital role because data sharing plays a significant part in this learning system. Cloud takes the responsibility of data sharing security and also the load management during the peak hours of access without affecting the network band access. The cloud helps increase the storage space if the data content are posted more by the users and also during peak hours the total number of user who uses the system are increased so that the load has to be tolerated automatically. The web search found that organizations of all sizes use mobile

devices for learning because technological advances meant that there is no longer the need for large infrastructure and support costs. Even small enterprises could deliver mobile learning simply by structuring learning around web-based content that could be accessed from web enabled mobile devices. Under a cloud computing environment, there is no other requirements for mobile devices except the computing power to run the browser. As such, a general mobile is enough to meet this requirement.

#### Survey on the Cloud Based M-learning Adoption Scenario in a Developing Country, Bangladesh.

A study was carried out among Information Technology and Computer Science departments in Bangladesh Universities to examine Cloud based M-learning adoption readiness, more specifically computer technology. It was motivated by the promulgation of the Long Term Vision 2021 with the aim to make Digital Bangladesh an information society to determine the perceptions of IT leaders about acceptance and using technology. The aim of this research was to find out the likelihood of Cloud Computing based M-learning technology adoption in Bangladesh, specifically among higher educational institutes.

#### *Questionnaire Design*

This section presents the structure of the survey by providing details of each question and its contribution to the research problem and the development of the proposed framework. The questionnaire has three sections. The first section of the survey questionnaire aims at understanding the respondent responsibility, nature of their organization, their role in IT decision making, size of their organization, and geographical locations. This was important because personnel at different levels of management, with different levels of involvement in IT decisions may have different understanding of technology and its impact on the organization. Also the geographical location of the institution is affected by legislation and compliance issues. The organization size is also important as it affects how different systems and SLA are managed. This section consists of questions 1 to 7. In this phase, it contributes to an internal analysis of existing systems, security practices and policies, legal and compliance issues and how they may be affected by the move to cloud.

The second section of the survey questionnaire of

questions 8 to 13 aims at understanding the drivers for adoption, perceived appropriate cloud service deployment and delivery model and the type of IT or business processes that educational institutes are willing to outsource to cloud computing. This allows the researchers to analyze any changes in practitioners understanding of cloud computing and its benefits. In the proposed architecture, the importance of this is in the planning phase where the organization is to select the appropriate cloud infrastructure and platform.

The third section of the survey consists of questions 14 through 20. In this section, the survey aims at understanding the characteristics that are considered a key to vendor selection, key concerns for vendor trustworthiness, and barriers to adopting cloud computing. An understanding from the organizational perspective of these factors is important in the development of the roadmap and architecture. This helps in the roadmap phases such as planning, adoption, migration, and management. The results from these questions also help researchers to compare with results from previous researches and see if there are any changes from the organizations perspective.

### Methodology and Data Collection

The sampling method is the cluster random sampling. Seventy Universities were randomly chosen from a population of 102 Universities in Bangladesh

considering public and private, technical and non-technical, from capital as well as from other parts of the country. Questionnaires were administered to the head of the department of IT and Computer science randomly selected universities using the purposeful sampling. A total of one hundred and forty questionnaires were distributed to the universities that constituted the sample for this study. Departmental heads and senior teachers were selected because it is assumed that they are leaders in education and therefore they play an important role in the adoption and use of computer technology based on the literature which has established that IT experts are expected to be change agents and to be effective leaders in the information era.

### Results and Discussions

Figure 3 shows the factors that significantly impact Bangladeshi Universities to adopt cloud based m-learning technology as a tool for facilitation of higher education. The poor knowledge of the users about cloud equally dampens their perceived various benefits of cloud computing in research, teaching, and learning. Bangladeshi institutions are yet to have a full understanding of the extent to which cloud computing could facilitate research, teaching/learning and general resource sharing; which could ultimately lead to reduction in expenses for the universities.

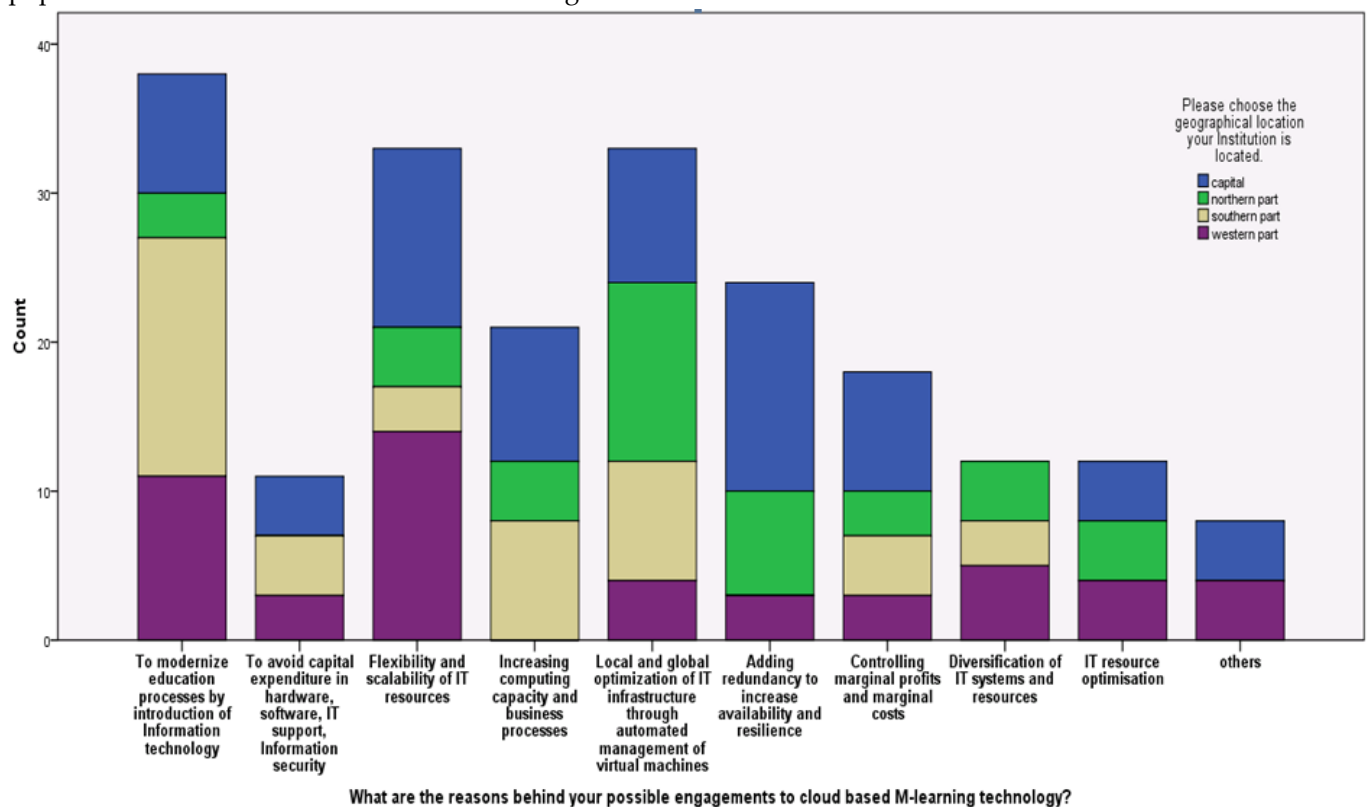


FIG. 3 REASONS BEHIND ADOPTION

Figure 4 also shows the barriers as another significant factor affecting the adoption of cloud technology in the Universities. The availability, stability and also the adequacy of ICT facilities (e.g. internet access,

bandwidth size, software, personal computers, communication cables, and routers), security facilities (like firewalls) are examples of conditions that could facilitate efficient cloud connectivity.

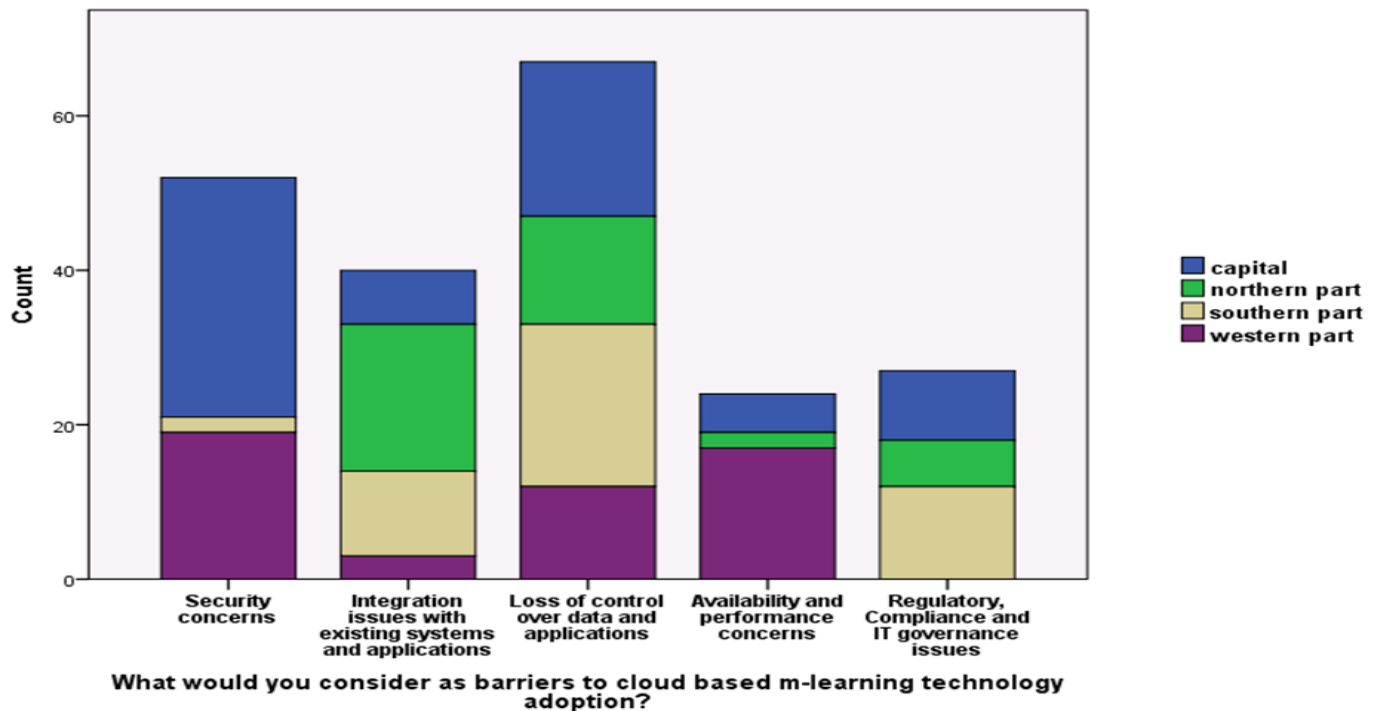


FIG. 4 BARRIERS FOR ADOPTION

#### Criteria for Cloud Selection Based on Survey

Drivers for considering cloud computing solutions for educational institutes should be identified in the context of the institutional strategy and how well they

align. The main drivers for adoption of cloud computing within institutions are economic, relating to the reduction in funding and the need to increase competitiveness through better student and staff experiences. Some of the essential selection criteria are furnished in Fig. 5.

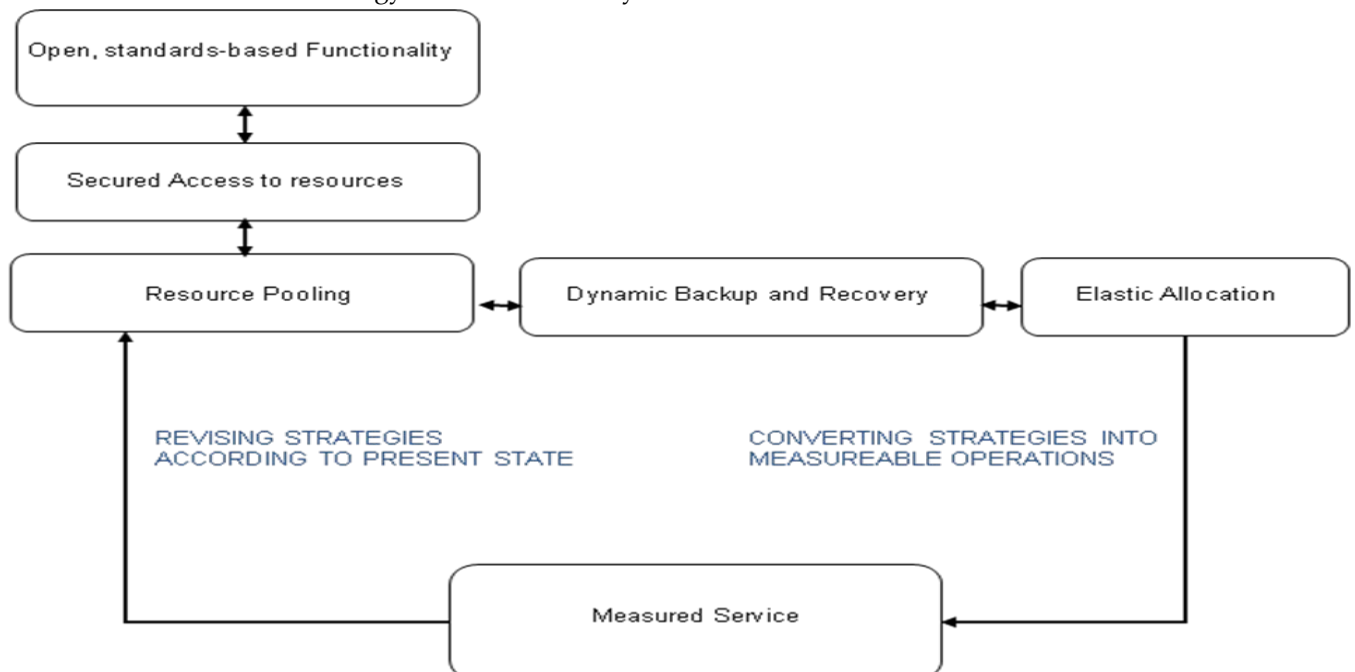


FIG. 5 INTERRELATION OF THE CRITERION FOR CLOUD SELECTION

### ***Open, Standards-based Functionality***

Platform as a Service (PaaS) offerings is occasionally based on proprietary languages and hosting providers. Educational Institutes should choose an open, Java-based framework for SaaS applications. An institute can unilaterally provide computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service's provider.

### ***Secured Access to Resources***

A robust SaaS application requires secure data access to ensure that each user/student/staff sees only data that belongs to their tenant. Best practice design gives each table a tenant identifier column and filters all queries using that identifier. Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g. mobile phones, laptops, and PDAs).

### ***Resource Pooling***

The provider's computing resources are pooled to serve multiple consumers like teachers, student, and staff using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to academic demands. There is a sense of location independence in that the students generally have no control or knowledge over the exact location of the resources but may be able to specify locations at a higher level of abstraction. Examples of resources include storage, processing, memory, network bandwidth, and virtual machines.

### ***Dynamic Backup and Recovery***

It was suggested for our proposed ESaaS (Education Software as a service) to add student-specific data extensions without affecting the overall data schema. Best practice designs include using a pre-allocated field in each table to hold customized XML data extensions or using name/value pair tables. ESaaS users are uneasy about entrusting all data and backups to a SaaS provider. When an application server fails, users should transparently fail over. Similarly, when a database server fails, the application should fail over to a backup server instance and restart a new backup server.

### ***Elastic Allocation***

Capabilities can be rapidly and elastically provisioned,

in some cases automatically, to quickly scale up capacity. The capabilities can then be rapidly released when additional capacity is no longer required. End users have been trained by Web 2.0 applications like MyYahoo and FaceBook to expect that the application user interface is under their control. A drag and drop framework for enabling end users to configure their own dashboards is essential for a competitive SaaS offering. The cloud architecture should include the capability that dynamically expands and contracts the pool of application and data servers.

### ***Measured Service***

Cloud systems automatically control and optimise resource use by leveraging a metering capability at a level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts). Resource usage can be monitored, controlled, and reported, providing transparency for both the provider and consumer of the service utilised.

### **Conclusions**

The digital revolution today has carried education into a completely new era where teaching and learning take place not only at schools, but at homes and in the workplace. Electronic Learning provides the ability to harvest the power of technologies to make the learning experience more effective and enjoyable. Today, we are witnessing the emergence of a connected, mobile society, with a variety of information sources and means of communication available at anywhere. Within this context, wireless mobile technologies are also adopted in educational fields. M-learning is not only a matter of learning or mobility, but a totally different concept, which is part of a new conception of mobility of a connected society. E-learning has taken learning away from classrooms, and yet m-learning takes learning away anywhere and anytime. While e-learning is an alternative to classroom learning, m-learning is the complementary activity to both e-learning and traditional learning. Nowadays technology allows users to carry the large numbers of resources in their pockets and to access them wherever they find it convenient in ways of using portable devices such as PCs, smart phones and hand-held. While the chances supplied from the use of portable devices for m-learning are completely new, the challenges as a consequence of the small screens, limited processing power, inputting capabilities, resources and small memory capacity, etc. are still prevalent.



This paper has presented a new architecture of a mobile learning system in a Cloud Computing environment enriched with mobile and wireless devices. An interactive mobile learning system in a cloud environment has provided a practical and cost-efficient solution. Mobile devices nowadays are widespread and provide great multimedia capabilities, which makes the delivery of mobile learning a more realistic approach since it can provide just in time learning on the move.

The adoption or shift to a cloud based M-learning environment by an organization, however, is not straight forward and poses several challenges (e.g. security, privacy, and interoperability). The development of a gradual and iterative systematic cloud adoption and improvement approach may prove to be more helpful, less risky and highly appropriate under a variety of circumstances. This paper has represented an important development in the area of cloud based m-learning adoption process, investigating IT professionals' thoughts on cloud based higher education systems in M-learning arena and exploring the key factors that may influence cloud based solution adoption in Bangladesh Educational Institutes.

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